REMARKS

Attached herewith is an excess claims fee letter for one excess total claim.

Claims 1-48 are all the claims presently pending in the application. New claim 48 is added for a clarification of the present invention consistent with the wording of original claims 28-30 that the antenna is monolithically integral (e.g., monolithically attached) to the waveguide.

It is noted that Applicant specifically states that no amendment to any claim herein should be construed as a disclaimer of any interest in or right to an equivalent of any element or feature of the amended claim.

Claims 1-5, 10-16, 21-23, 34, 37, 39, 46, and 47 stand rejected under 35 U.S.C. § 103(a) as unpatentable over U.S. Patent No. 6,563,185 to Moddel et al. As best understood, the claims unidentified in this listing are also intended to be rejected as unpatentable over Moddel. Applicants request that the Examiner make formally of record the full intent of the rejection identified in paragraph 3 on page 2 of the Office Action dated March 6, 2006.

This rejection is respectfully traversed in the following discussion.

I. THE CLAIMED INVENTION

As described and as defined in, for example, independent claim 1, the claimed invention is directed to an apparatus for producing a modulated optical signal in a waveguide, and includes an antenna for communicating with the waveguide and with an externally-applied optical field and having an output port. An electrically-variable-impedance device is connected at the output port of the antenna and is capable of responding at a frequency of an externally-applied optical field and having its impedance at the optical frequency changed by an applied electrical signal.

As explained beginning at line 19 on page 2 of the specification, the present invention addresses the problem that there are no monolithically integrated optical interconnection technologies, so that each has required hybrid construction to route logic signals through a laser driver, laser, waveguide, photodiode, and transimpedance amplifier chain. Moreover, as described at lines 5-9 of page 3, there is a separate laser or modulator provided for each fiber or waveguide, thereby requiring that each line have at least one component mounted on the circuit board or chip.

In contrast, as explained beginning at line 7 of page 6, the present invention offers a number of advantages, including the capability of using a single common laser and driver circuit for a plurality of interconnects, thereby providing savings in chip real estate, extremely large bandwidths and near-zero latency, considerable power savings, and the capability of manufacture entirely in monolithic silicon circuitry.

Moreover, the present invention is unlike an ordinary antenna that must couple into free-space waves. Rather, the present invention, although called an "antenna", is perhaps technically better described as a "waveguide to conductor coupling", since it does not address the free-space propagation purpose.

II. THE PRIOR ART REJECTION

The Examiner alleges that Moddel renders obvious the present invention. Applicants submit, however, that there are elements of the claimed invention which are neither taught nor suggested by Moddel.

Although the same word "antenna" is used for both the present invention and the prior art described in Moddel, they are not the same devices, although the popular word "antenna" could be used for both. The present invention would be just as properly described more technically as being a "waveguide to conductor coupling structure."

In contrast, Moddel's antennas are not described as being anything except free-space devices, in the normal sense of the word "antenna."

The antenna of the present invention is much more like a waveguide-to-coax adapter than like rabbit ears and would not be much use in free space. Nowhere does Moddel describe nor claim waveguides and his devices are based on two-layer tunnel barriers and are not interchangeable with the antennas of the present invention.

Because of this basic difference in environments and interface capability, the rejection based on Moddel is inherently deficient in failing to satisfy the plain meaning of the claim language, specifically, that of satisfying the interface with a waveguide.

In paragraphs 13 and 20 of the latest Office Action, the Examiner attempts to address this basic deficiency of Moddell by pointing to the optical fiber 140 shown in Figure 2F therein. However, Applicants respectfully point out that, to one having ordinary skill in the art, this optical fiber is not a "waveguide", as that term would be understood in the art.

The exemplary embodiments discussed in the disclosure and exemplarily illustrated in

Figure 3, clearly show the antenna structure as being monolithically attached to an SiO2 light cladding layer 330 (e.g., a "waveguide"). As clearly shown in Figure 7, wherein optical fiber 710 is exemplarily shown adjacent to the structure of the present invention, the present invention does not intend that "waveguide" be considered equivalent to "optical fiber".

Applicants submit that such distinction is too well established in the art for the Examiner to ignore, thereby simply ignoring the plain meaning of the claim language. The integral nature of the exemplary embodiments shown in Figure 3 was clearly articulated in original claims 28-30, which the Examiner likewise ignored, and Applicants have added new claim 48 to focus on this exemplary integral structure. However, Applicants submit that even the original wording of all of the original independent claims is clearly distinguished from Moddell because there is no waveguide in this prior art reference to which the antenna structure communicates.

As Applicants explained in the previous Amendment, Moddell covers a lot of ground, but where it relates to the present invention, it basically takes prior art devices (optical detectors and frequency mixers (e.g., modulators) made from thin-film antennas and metal-insulator-metal tunnel junctions), and adds his actual invention, which is the two-insulator tunnel barrier. His antennas are all broadside-firing devices, so that the light comes in and out normal to the chip surface. Applicants submit that this method is just like everybody else's. Compared with the prior art discussed in the present application (e.g., Fumeaux et al., attached hereto in an IDS), there is no new teaching in Moddell that would make it more obvious to combine these devices with planar waveguides.

These devices have been known for over 30 years, and thin-film versions have been known for 8 years before the filing date (Wilke et al, 1994, attached hereto in an IDS) of the present application. Nobody before the present inventors produced or proposed combining them with waveguides, even though all the advantages discussed in the application were potentially available from the beginning. This is true even though these years covered the telecom boom, for which these devices are highly suitable. All prior art devices are broadside-coupled free-space devices.

Although these ACTJ devices have been known for 30 years at the time of filing, their efficiencies as detectors and modulators has remained very low. The best published results as of the filing date of the present application had efficiencies below 1%. The waveguide-integrated design of the present invention improves the coupling efficiency to the point where practical devices can be made. If this had been obvious, it would have been

done a very long time ago.

Moreover, Applicants submit that these devices only work with high index contrast waveguides such as silicon-on-insulator. Trying to make them with glass guides requires matching the area and angular spectrum of the antenna pattern to match the waveguide mode closely. Small antennas have wide radiation patterns - the product of the intercepted area times the receiving solid angle is equal to $\lambda^2/2$. Low index-contrast guides such as glass or silicon oxynitride have large cross-sectional area and small solid angle, which are a poor match to small metal antennas. Since the metal is so lossy in the infrared, Applicants submit that one cannot make large antennas that are efficient, so that one cannot match to low index-contrast guides. This is an additional reason why the use of these devices with silicon strip waveguides is non-obvious.

Applicants further submit that end-fire antennas fabricated on one lithographic level also do not work with low index-contrast types of waveguide, because the electromagnetic coupling between the mode and the metal is too strong: the first bit of metal the wave encounters splits the mode apart, sending one half into the substrate and one half into the top cladding. This is not a purely optical problem--a Yagi antenna for TV has a much wider pattern in the vertical plane than the horizontal plane, because it's so much wider than it is tall. Getting good coupling into a micron-sized waveguide is very difficult.

Turning now to the rejection, Moddell's one vaguely waveguidish thing is Figure 2F, which shows an ACTJ emitter shining broadside into a fibre containing a Bragg grating, which is understood to narrow down the spectrum of the light the way a laser does.

Applicants submit that this is a straighforward application of techniques long used with diode lasers, and does <u>not</u> constitute <u>waveguide integration</u>.

In contrast, the device of the present invention, in the exemplary embodiments discussed in the disclosure, is waveguide-integrated, meaning that it works in end-fire mode (parallel to the substrate), is fabricated monolithically with the waveguide, receives and transmits by the same waveguide, without ever leaving the structure, and is inherently tightly coupled to the waveguide.

Along this line, Applicants submit that Moddell cannot operate in the plane of the chip, and he would need two separate waveguides, one for input and one for output, which he cannot do because the substrate is in the way.

Waveguide integration provides many benefits not available to such standalone devices, especially broadside ones. For example, the packing density in Moddell is limited

by how closely the fibers can be spaced. In contrast, the present invention can be 1000x higher density, since the devices take up only a couple of square microns in the present invention, versus at least 10**4 square microns for an optical fibre. The present invention is also compatible with standard IC packaging, whereas the device in Moddell is not, because of all those optical fibres. Applicant respectfully submit that alleging that this aspect of the present invention is not novel over Moddell is like saying that the integrated circuit is not novel over the transistor.

Applicants also submit that the strength of the coupling of Moddell's devices to the incident field is low, as in all prior art antennas, which is a fundamental limitation to its use as a digital modulator, because digital modulators require a high on/off ratio in order to function correctly in the presence of noise, supply voltage variations, and process variations.

In contrast, the waveguide-integrated device of the present invention is highly suitable for use as a digital modulator because its strong coupling with silicon planar wire waveguides allows a high on-off ratio.

Hence, turning to the clear language of the claims, in Moddel there is no teaching or suggestion of: "... apparatus for producing a modulated optical signal in a waveguide, comprising: an antenna for communicating with the waveguide and with an externally-applied optical field ....", as required by independent claim 1. The remaining independent claims have similar language and concepts.

Therefore, Applicant submits that there are elements of the claimed invention that are not taught or suggested by Moddel. Therefore, the Examiner is respectfully requested to withdraw this rejection.

III. FORMAL MATTERS AND CONCLUSION

In view of the foregoing, Applicant submits that claims 1-48, all the claims presently pending in the application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Assignee's Deposit Account No. 50-0510.

Respectfully Submitted,

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